A New Algorithm for Cluster Leader Selection in Wireless Sensor Networks

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***Abstract*—Nowadays sensors play nearly a crucial play in our daily live. Because of their important impacts like investigation of non-reachable places for human kind, etc. Sensor networks consist of tiny sensors that can be homogenous or heterogeneous. Sensors will not mange by human so they have to be self- management. Most of Sensors works with low-producer-power like battery. In this paper, we propose a new solution to cluster sensor nodes in Wireless Sensor Networks.**

***Index Terms*—Fuzzy Logic, WSN, Clustering, IoT**

I. Introduction

Wireless Sensor Networks are widely used in various civil and military related applications. One of the most challenging issues is to manage nodes in environments that basically cannot be reachable or when its not possible to replace their power source. Many of WSN nodes today are supplied with rechargeable lithium ion/polymer batteries and polycrystalline cells to charge them by ambiance sunlight radiation. They include variety of sensors such as temperature, humidity, motion detection, light, UV or IR sensors. A pico-power microcontroller manages the node and a cmos low power transceiver provides the communication layer. However, the most hesitating part is to recover the captured information from dead nodes and to guarantee the transmission of captured data safely to the base station.

II. Related work

Qi Dong and Donggang Liu in [1] describes a new and novel distributed cluster head leader selection algorithm based on symmetric key operations that has three main characteris- tics: cluster nodes are consistent in cluster leader selection, relatively resistant against attackers which means attackers do not have any impact on benign nodes for cluster leader election decisions, and finally is a fault tolerant algorithm which recover messages that maybe lost or be changed via malicious attacks. Puneet Azad, etc in [2] present a new cluster head election algorithm that is based on fuzzy rule and also considered three main characteristics: remaining energy of nodes, number of neighbors, and distance from the base station or sink node and compare the proposed method with distributed hierarchical agglomerative clustering and show it has better performance in network life time Dilip Kumar in [3] introduce a new distributed stable algorithm that is used for cluster head election. The presented algorithm, DSCHE , is based on weighted probability, consider two aspects: remain- ing energy and the average energy of network, he showed that the algorithm is more stable and has better performance in comparison of conventional ones. One of the main drawbacks of this algorithm is the volume of data packets sent to Base Station rather than some of the known algorithms. Sohail Jabbar in [4] introduced a multilayer algorithm for clustering.it means it consider three centralized and distributed algorithms in order that it will reduce the number of cluster head candidates.to achieve this goal it use centralized algorithm or we can use distributed one. It also reduces message exchange and use communication architecture and design architecture.

III. Using Fuzzy Inference Systems in Clustering

Fuzzy logic is a useful decision-making system, without need to full information about the environment. On the other hand the normal control mechanisms generally require ac- curate and complete information about the environment [5]. Fuzzy logic can make decisions based on a variety of environ- mental parameters, combining them according to predefined rules are used. Some clustering algorithms are used fuzzy logic to overcome the problem of uncertainty in wireless sensor networks. The fuzzy clustering algorithm (FCA) is use fuzzy logic to combine different parameters to select a cluster head. In accordance with a de-fuzzy output of system, they report the chances of cluster head that is achieved with IF-THEN rules [6-21]. A node will be a cluster head if it has the most chance to their adjacent nodes. Fuzzy logic methods can be distributed or centralized. In this paper, we try to use the fuzzy system to solve the problems of previous systems and presented the optimal algorithm to select the cluster head [71-90]. The proposed clustering algorithm is based on LEACH which functionality and reliability is improved by fuzzy systems. LEACH Protocol is one of the first and most famous hierarchical protocols that is Provided for wireless sensor networks [6-9]. In this protocol, Network activity is divided into time periods (Figure 5). At the beginning of each period, selected number of nodes as a

$$T(n)=\begin{cases}\dfrac{P}{1-P\times(r \bmod \dfrac{1}{p})}, & if\ n\in G\\ 0, & otherwise\end{cases}$$

cluster head randomly. For this purpose, each node produces a random number between 0 and 1 [10]. If this number is less than the T (n) that is achieved using Equation 3, the node as cluster head is introduced. In relation (1), P is ratio of the number of clusters and the total number of network nodes, r is number of Course, and G is the numbers of nodes in the 1 / P previous are not selected as cluster head [11-18, 91-108].

After defining the cluster head node, other nodes based on the received signal strength from each cluster head, decide to become a member of each cluster. Cluster head node divided the range of their responsibilities into several time slices (Figure 1).This time slices are sharing based on TDMA mechanism between members of cluster [19-24]. In each time slices, cluster head communicate with one Clusters members and receives its information packets [25]. In every some time slices, Cluster head sends received Information from its members to the central node. In order to distribute the load on different nodes after a period, for the beginning of a new era, cluster head based on the mechanism described above are changed [26-30]. In short, the LEACH algorithm is as follows:

A. Notification phase (advertising):

Each sensor selects a random value between 1 -0.If the random number is less than a threshold T (n), in this case, the node selects itself as a cluster head. While the P is percent of needed cluster head, r is number of current period And G is a fraction of the nodes that is not be a cluster head in the 1 / P last period. Using this threshold, each node in each 1 / P period will be a cluster head. In the first round all nodes can be cluster head with probability P [31]. In the next period increases the probability of selection nodes that are not selected as the cluster head. The method presented in this study, this possibility is described by fuzzy inference system that continues to be expressed in detail below, will be calculated [32]. Each node is selected as cluster head node sends a message broadcast to the other. All cluster heads send their announcement messages with the same energy.

ADV = nodes ID + distinguishable header

After this stage, the non-cluster head node, choose their cluster head which they belong. If a non-cluster head node receives several announcement messages will be join to the close cluster head. (Closely is detected by the strength of the received signal). In the same case a cluster head to be selected randomly.

B. Cluster formation Phase

In this phase, each node after determined that is which cluster to it belongs must deliver this issue to the cluster head of that cluster [33-35].

Join-REQ = nodes ID + cluster-head ID + header

C. Forming phase schedule

At this stage, cluster head received all Members join messages and based on the number of them, constitute a TDMA schedule and send information for each node.

D. Data transfer phase

After the clusters were formed and fixed TDMA, Data transfer can be started. Each Non-cluster head node radio device, it can be turned off until the time of notification that node. In the proposed method the amount of chance of each node to parent (phase announcement) is calculated using a fuzzy system [42, 60]. Fuzzy system that is used is Mamdani type, with three inputs and one output. The defuzzification of output is used to find the center of mass method, which is the most popular method among seven defuzzification of the output [36, 41, 62-90]. Overview fuzzy system and its features can be seen in Figure 2.

$$T(n)=\begin{cases}\dfrac{P}{1-P\times(r \bmod \dfrac{1}{p})}, & if\ n\in G\\ 0, & otherwise\end{cases}$$

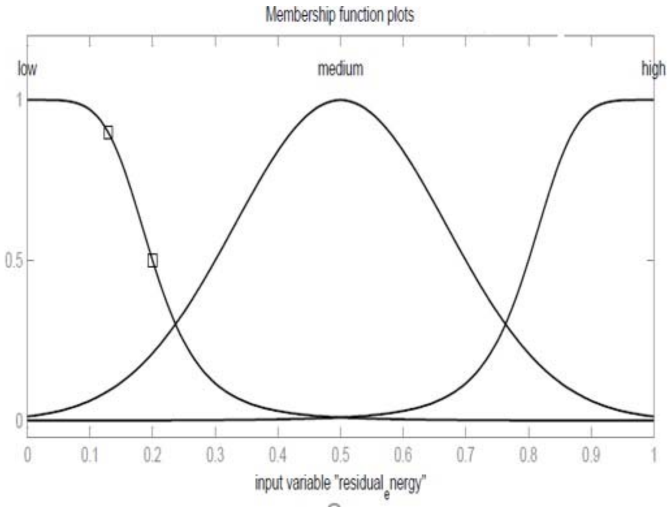
Membership functions for the fuzzy system have been obtained experimentally and testing and optimization. Inputs and outputs are defined as follows:

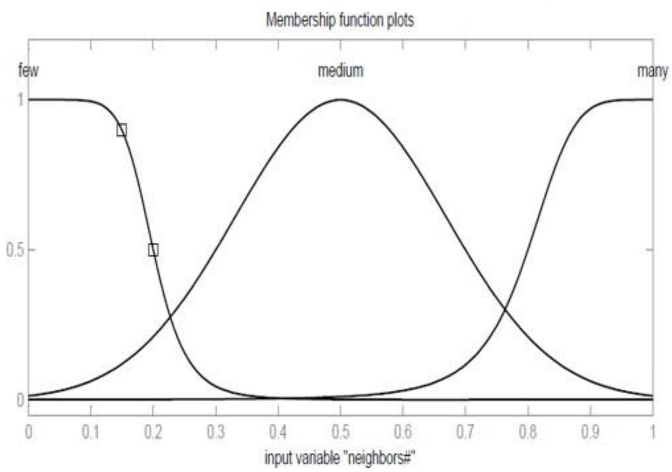
a) The first input (residual energy): Show the remaining amount of energy of each node. Whatever the amount of energy is higher can send and receive more information and lifetime is higher.

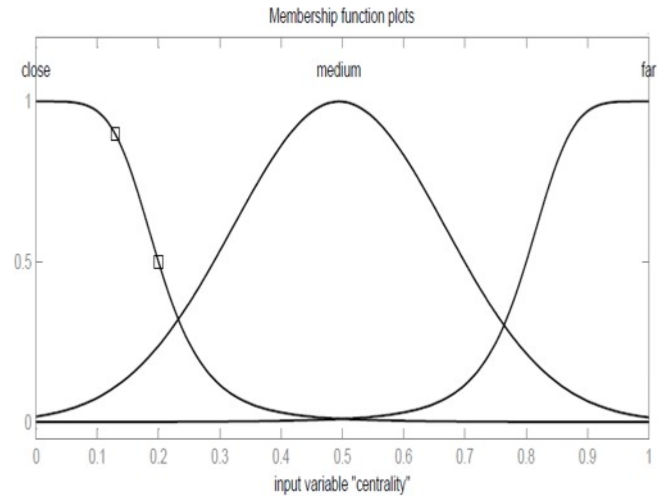
b) The second input (neighbors): Shows the number of each node neighboring. Nodes that have more neighbors will have a better chance of be parent [36, 37]. The proposed method is calculated based on the number of neighbors. In this method, the following formula is used:

$$N = 1 - e^{-\gamma \pi R^2}$$

Where, R is the radius of the neighborhood and the 0.01 = . In the algorithm running neighbor radius is considered 15 meters. The third input (centrality): show the distance of a node from the central node. Less distance a better chance of becoming a parent will make. Output (chance): combine three input value by fuzzy rules defined, the chance of a node for become parent node being obtained fuzzy system output. Input and output membership functions in Figure (3) are observed [38-40, 42].







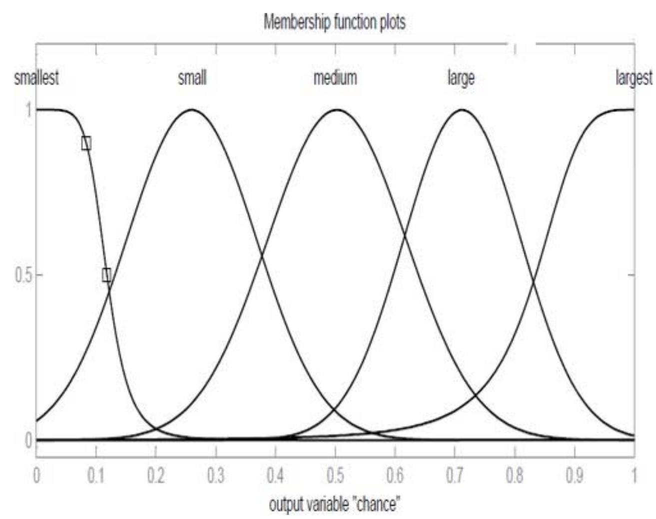


Fig. 1. Figure 3 - (a), (b) and c)) input membership functions, (d) output membership function of the fuzzy system

Input values are defined by fuzzy rules, which combined to produce output. For this fuzzy system are defined 18 laws as follows: 1. If (residual energy is low) and (neighbors is few) and (centrality is far) then (chance is smallest) 2. If (residual energy is medium) and (neighbors is few) and (centrality is far) then (chance is smallest) 3. If (residual energy is low) and (neighbors is medium) and (centrality is far) then (chance is smallest) 4. If (residual energy is low) and (neighbors is few) and (centrality is medium) then (chance is smallest) 5. If (residual energy is low) and (neighbors is medium) and (centrality is medium) then (chance is small) 6. If (residual energy is medium) and (neighbors is medium) and (centrality is far) then (chance is small) 7. If (residual energy is high) and (neighbor is many) and (centrality is close) then (chance is largest) 8. If (residual energy is high) and (neighbors is medium) and (centrality is close) then (chance is large) 9. If (residual energy is medium) and (neighbors is many) and (centrality is close) then (chance is large) 10. If (residual energy is high) and (neighbors is many) and (centrality is medium) then (chance is large) 11. If (residual energy is medium) and (neighbors is medium) and (centrality is medium) then (chance is medium) 12. If (residual energy is medium) and (neighbors is many) and (centrality is medium) then (chance is medium) 13. If (residual energy is medium) and (neighbors is medium) and (centrality is close) then (chance is medium)

14. If (residual energy is medium) and (neighbors is medium) and (centrality is far) then (chance is medium) 15. If (residual energy is medium) and (neighbors is few) and (centrality is medium) then (chance is medium) 16. If (residual energy is medium) and (neighbors is many) and (centrality is medium) then (chance is medium) 17. If (residual energy is low) and (neighbors is medium) and (centrality is medium) then (chance is medium) 18. If (residual energy is high) and (neighbors is medium) and (centrality is medium) then (chance is medium)

An example of how to combine inputs to produce an output is observed in Figure (4) and (5) [90-101].

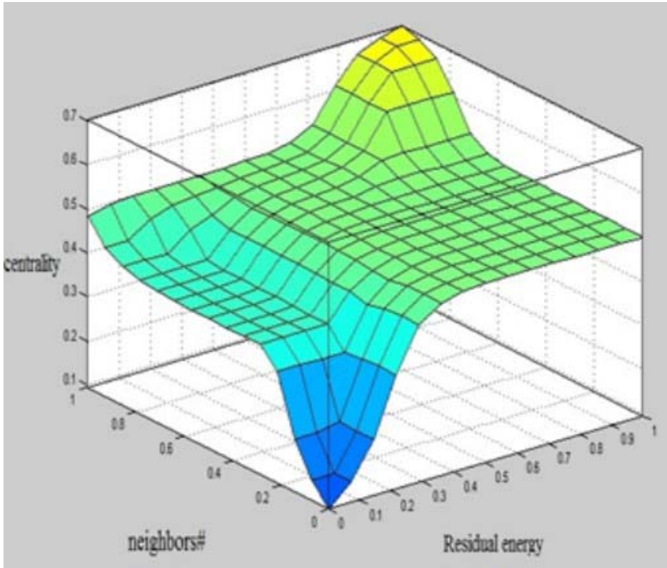


Fig. 2. Figure 4 the combination of input parameters

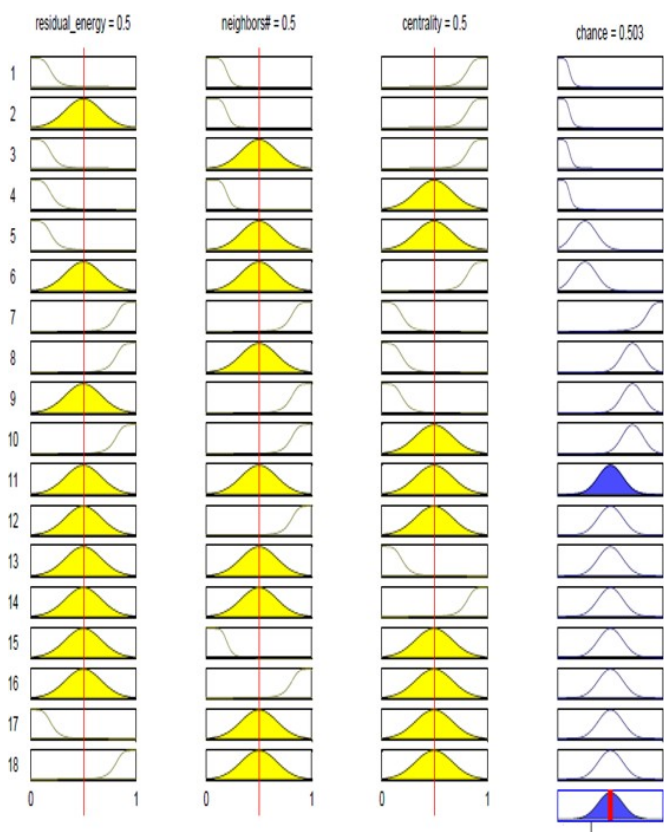


Fig. 3. Figure 5 the combination of inputs to produce outputs

To examine design methods, a network with 100 nodes consider that are randomly distributed. Other network parameters to be entered in the following the proposed algorithm:

xm=100; ym=100; sink.x=0.5*xm; sink.y=0.5*ym; n=100 p=0.1; Eo=0.5; ETX=50*0.000000001; ERX=50*0.000000001; Efs=10*0.000000000001; Emp=0.0013*0.000000000001; EDA=5*0.000000001;

IV. Network Model

At first, we will explain the characteristics of the used system model. First we expressed our assumptions about the Network Model. As review the designed method:

1) A network with 100 nodes and a random distribution.
2) Network will consider in the 100m 100m.
3) Base station coordinates [50.50] is considered.
4) The amount of initial energy is equal 0.5 Joule.
5) And the initial probability is assumed to be 0.1.
6) All sensor nodes have the same energy in the arrangement stage.
7) All nodes and sink after the arrangement are fixed.
8) All sensor nodes have the same computing power; memory and energy or homogeneous in terms of form.
9) The distance between nodes can be calculated based on the intensity of the received signal.
10) Therefore sensor nodes do not need to be aware of their exact location.

V. Radio energy model

Radio energy model for k-bit packet transmission, In the distance d meter, In the simulations is as follows: As well

$$E_{Tx}(k,d) = \begin{cases} k * E_{elec} + k * \varepsilon_{fs} * d^2, d < d_0 \\ k * E_{elec} + k * \varepsilon_{mp} * d^4, d \geq d_0 \end{cases}$$

as radio energy model to receive a k-bit packages, is as follows: Depending on the distance, the consumed energy has been expressed in channel model by fs and mp. Eelec is the amount of energy required to run the transmitter circuit or receiver. Radio parameters used in the simulation are set as follows: Eelec=50 nJ/bit EDA=5 nJ/bit/report fs=10 J/bit/m2 mp=0.0013 J/bit/m4

Algorithms for different numbers of repeats, is examined. After about 1,000 around the optimal cluster head, will be achieved.

$$E_{Rx}(k) = E_{elec} * k$$

For evaluation, we compare it with Leach algorithm and FCA solution from remaining energy evaluation metric and number of live nodes.

VI. Conclusion and Future Work

In this paper a new algorithm was proposed for routing in WSNs. Then a comprehensive evaluation, discussion, comparison with other methods was done. One of the drawback

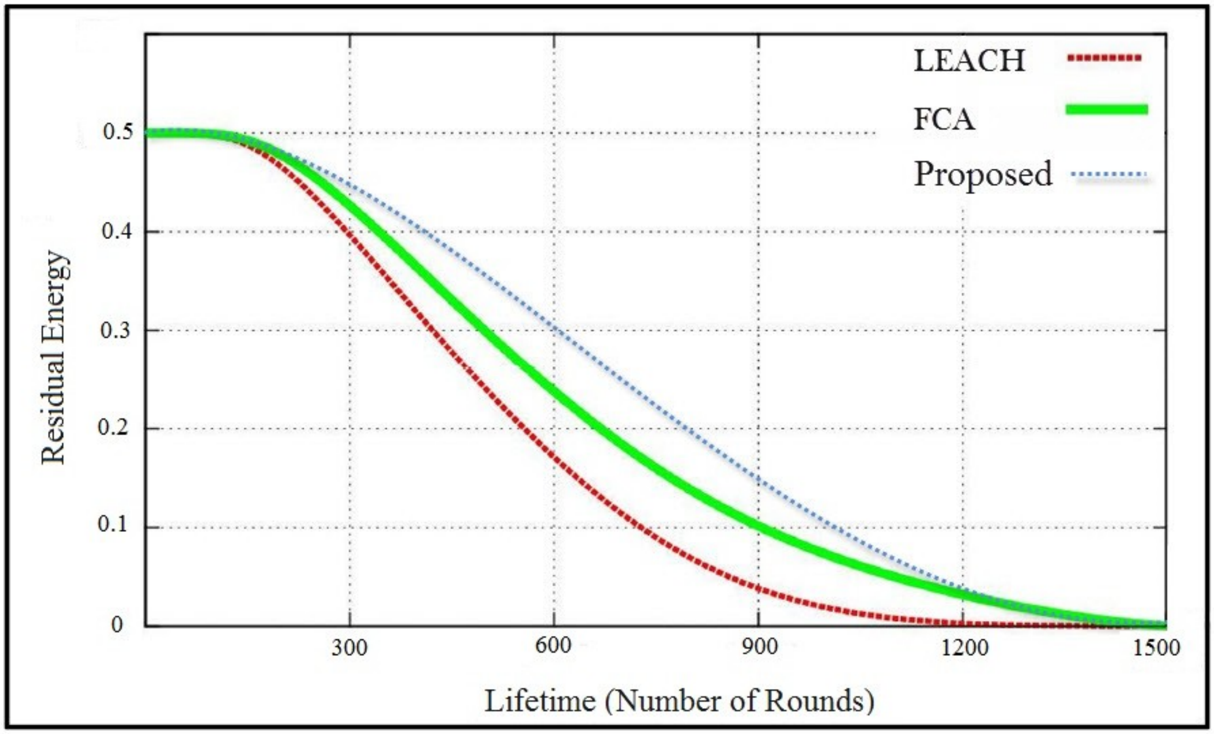


Fig. 4. Remaining energy

of this method is this it will not considering the privacy and security. One possible future work is that we can use other technologies such as machine learning methods in order to enhance clustering selection method.

VII. Conflict of Interest

No potential conflict of interest was reported by the authors

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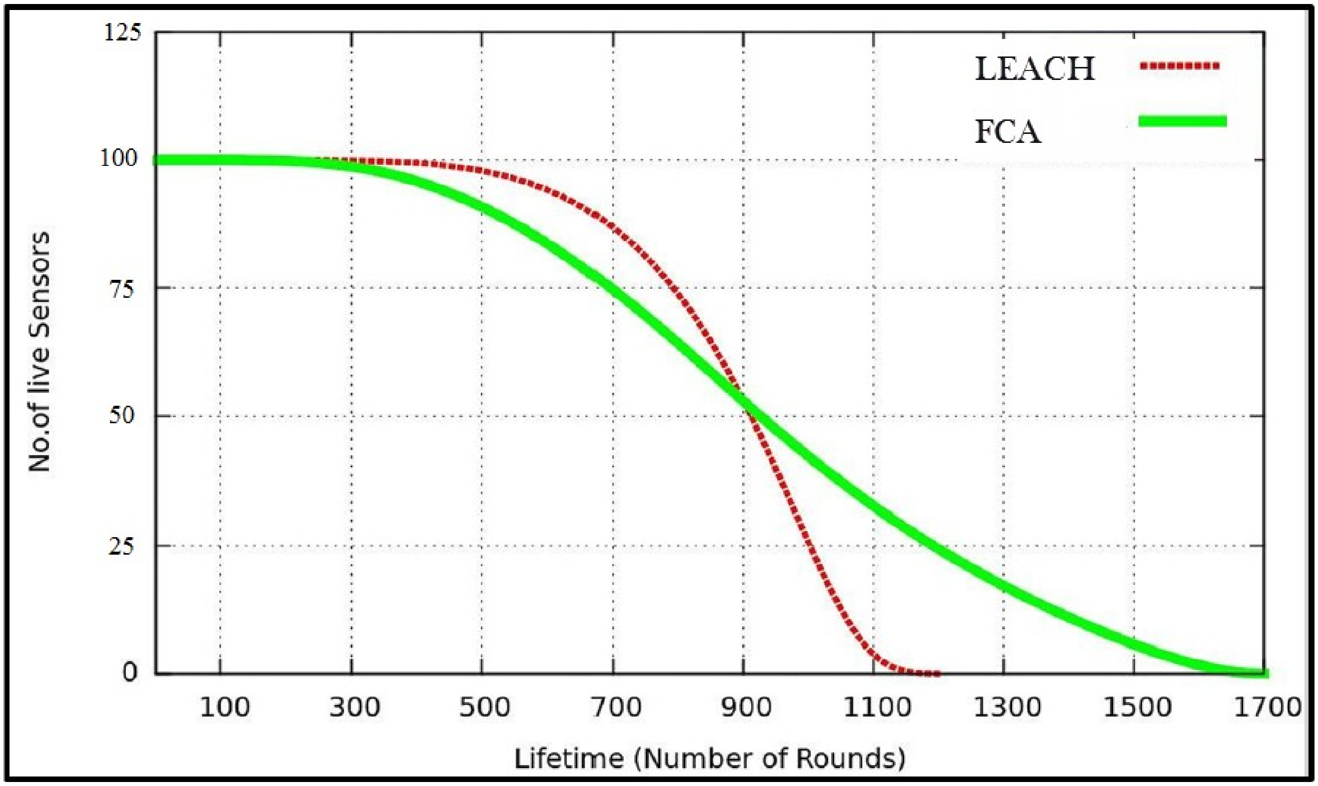

Fig. 5. Live nodes

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